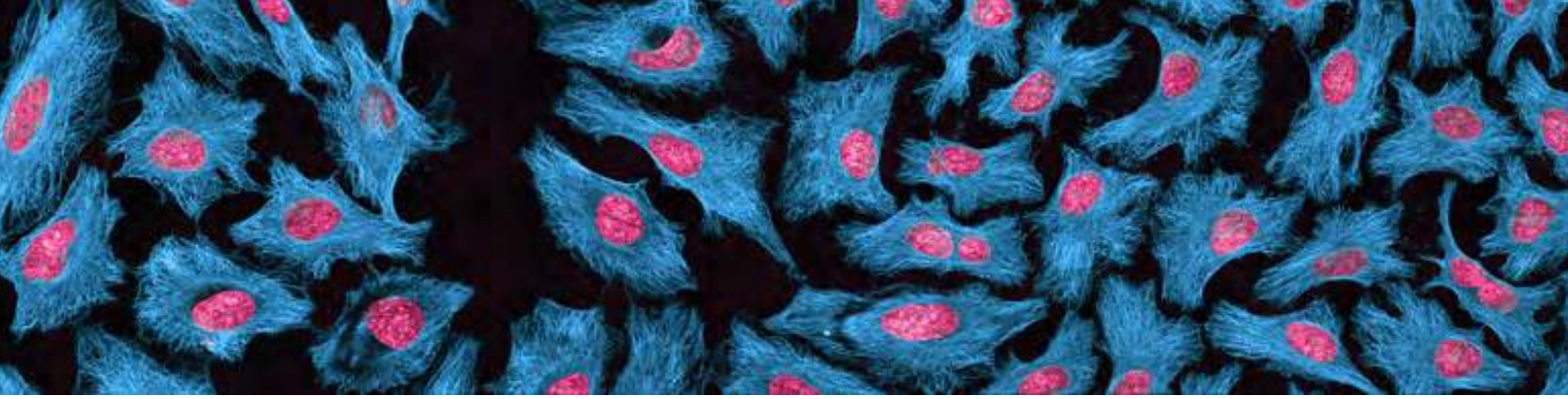
ISLAND SCHOOL SCIENCE JOURNAL '17

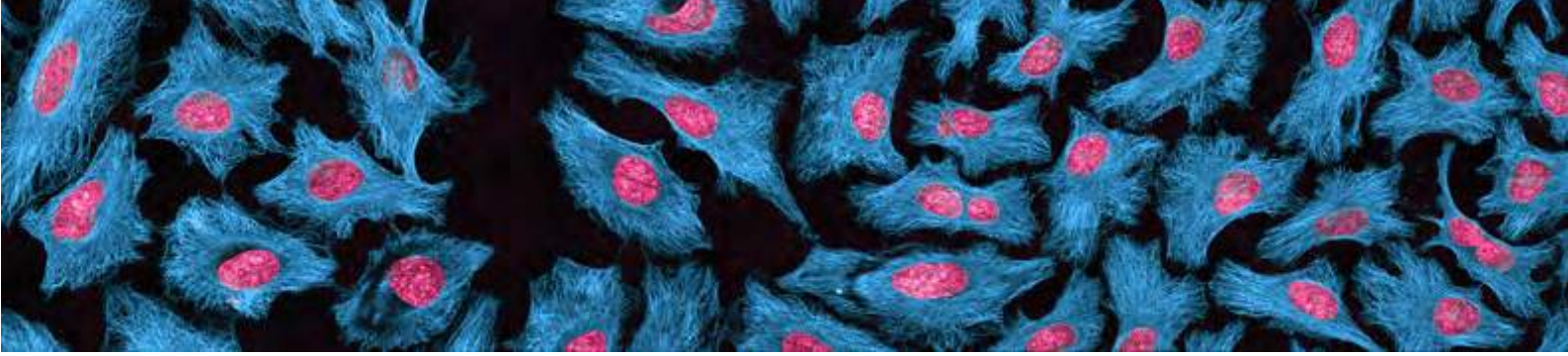
A COLLECTION OF ARTICLES WRITTEN BY STUDENTS OF ALL AGES



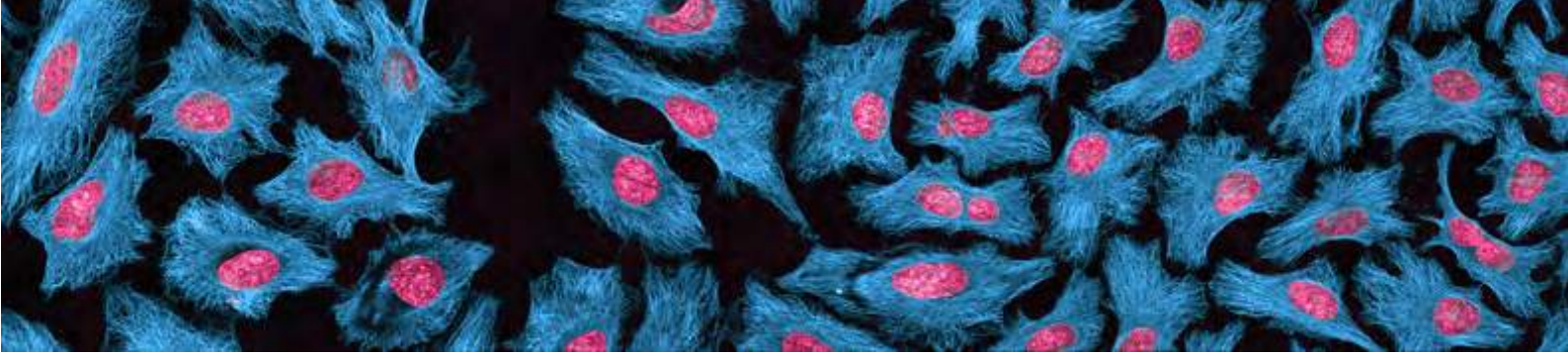
Welcome!

The Island School Science Journal is a collection of science-related articles written by Island School students of all ages, from all years. Many are inspired by recent research and news stories in a broad range of science and technology related areas. We encouraged students from all over the school to submit articles, so we ask that you please keep in mind the age of the author when reading the articles.
We hope you enjoy the 2017 Science Journal.

Happy reading!
Editors Dharesha Jhaveri & Millie Cummins



Contents



Contents

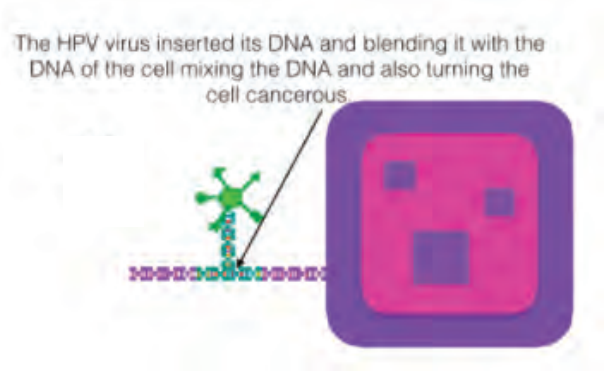
How One Cell Can Save Many

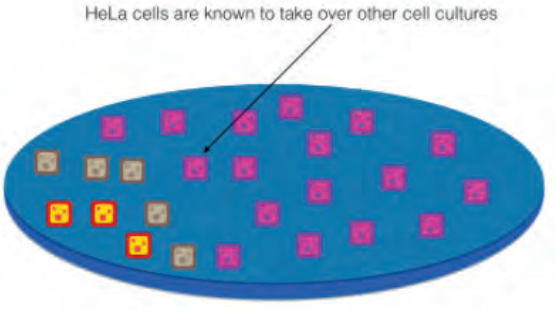
Hugo Dernoncourt Year 7

Almost 66 years ago, the HeLa cell was discovered and since then it has has been saving lives.

On February 8, 1951 a tissue sample was taken from the cervical cancer patient Henrietta Lacks. That tumour sample had special properties. The sample was given to George Gey who was able to isolate a single cell from the tumour and managed to grow a cell line from it. Unlike other cell cultures these cells were capable of dividing indefinitely and did not die after a while like other cell lines. George Gey named the cells HeLa after the first two letters of the patient's first and last name. Sadly Henrietta died on October 4 of that same year and her cells were sent all over the world for research without her family's knowledge for decades to come.

HeLa cells caused a enormous boom in medical research because for the first time, scientists were able to have consistent tests on the same base without it dying, as normal cells have a division limit and do not fare well outside the human body. Soon the cells were used to test on diseases like AIDS, Measles, Mumps, Ebola and many more. They are also used to test more simple products like tape, glue, pens to see if they are irritants or harmful. The cells had a stable division rate allowing thew to take up the polio virus and enabling the development of the vaccine and by 1954, the vaccine was fully developed. HeLa cells have also helped to develop genetic research by helping a scientist discover a chemical that makes chromosomes visible. HeLa are the first human cell to have been cloned and even sent into space. After being used so many times the cells have produced 20 tons of biomass. it cost only 11 US dollar to buy a bundle of HeLa cells which also explain how far reaching its benefits on research have been.





HeLa cells constantly mutate creating new strains of immortal cells that are also used today. Other immortal cell lines have been also created by genetic engineering but the original HeLa Line is still the most used. Since HeLa cells are technically cancerous they are not considered to be completely human and they even blended with the HPV virus which caused the cells to become cancerous (p2) in the first place. This could explain partly why it is different to normal cells and therefore immortal and able to produce telomerase

an enzyme that repairs the cell's DNA protection system and enables it to multiply indefinitely.

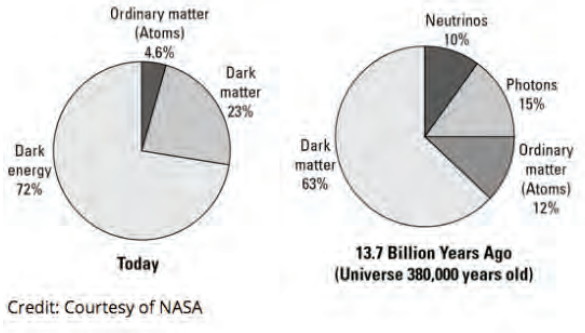
It is amazing that such small events have had such a big impact on medical research. It was very fortunate that these events happened as Henrietta was in the poor minority and could maybe not have afforded the operation in the first place. In addition, the tissue sample may never have been brought to George Gey or never have been extracted in the first place. A difference is a thing anybody can make. In Henrietta's case she saved thousands of lives and helped the progress of medical research worldwide. It is a shame she was never thanked for her meaningful contribution to our lives.

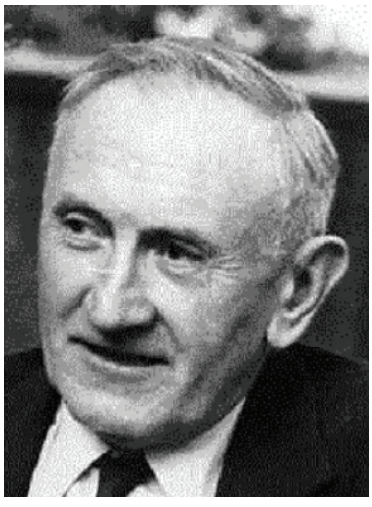
What is Dark Matter?

Priscilla Lee Year 10

Amongst the vast field of physics, one of the most prominent theories is the theory of dark matter, which is still a relatively new idea.

Dark matter is an unknown type of matter, making up roughly 23% of our universe. It cannot be seen, due to the fact that light cannot detect it, nor does it emit electronic radiation to be detected by current technology. It's existence can only be inferred through its gravitational pull on matter that we can see, it's influence on the universe's structure, and the thermal radiation left from the Big Bang.





Discovery of Dark Matter

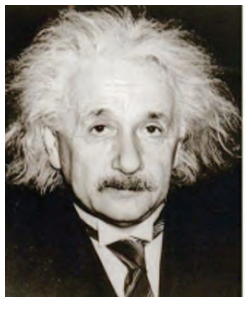
Dark matter was discovered, or at least noted, in 1933, when an astronomer, Fritz Zwicky discovered that a cluster of stars (the Coma Galaxy Cluster) was missing some mass. He quickly realized that the mass was not actually missing, but it simply could not be seen. These galaxies were spinning so quickly, that it was simply impossible for the stars to stick together. From this, he inferred that the gravitational pull of the unseen mass was the force holding the cluster together, although he did not know what it was, hence the name Dark Matter. From then on, the theory was expanded upon, although not much is known about it. It is believed that there can be galaxies made mostly from dark matter, which was proven by the existence of Dragonfly 44, a galaxy with the mass of the Milky Way, which had so few stars it had previously been overlooked by scientists.

Recent Studies

Physicists have recently proven its existence, through the collision of two galaxies. This discovery may well be one of the most important ones ever made in the field of physics. The existence of Dark Matter may very well open up a new unknown field in astrophysics, and even the discoveries of previously unseeable substances. Dark matter is also important to understanding the size and shape of the universe, due to the fact that it can tell us whether the universe will continue to expand, collapse or reach equilibrium. Other than that, Dark Matter generates an exceedingly strong pull that is keeping galaxies together as they spin. Exerting a force greater than gravity, without it, our world wouldn't exist.

What is Dark Energy?

To be honest, more is unknown than known when it comes to dark energy. Scientists have deduced that it is 'a property of space', making up approximately 72% of the universe, helping it expand faster. It was first observed by Einstein in 1917, although he had not realized that the universe is constantly expanding. However, he had inserted a term called 'cosmological constant' to predict a stationary universe, which was the main belief of most physicists at the time. Even after Edwin Hubble discovered that the universe was actually expanding, scientists continued to use this term to explain an unknown force, which we now call dark energy.
This repulsive energy has been found to be pushing the universe apart, and is slowly accelerating the expansion. This was later proved in 1998 when scientists discovered that some supernovae were a lot dimmer than expected. The only way this could be explained is the fact that the supernovas were moving further away much faster than physicists had anticipated, and that there had to be an invisible force pushing them away.



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The Future?

There have been many theories throughout the years about what may happen in the future, although they have been mainly narrowed down into 3 prominent ideas.

The first of which is the indefinite expansion of the universe, also known as the ‘Big Chill’. This would be when there is too little matter, and gravity isn’t strong enough to pull everything together. Galaxies, stars, planets would slowly drift apart, but will never stop. The universe would continue growing and growing, until eventually, the stars and galaxies are so far apart that the universe ends up in a cold, dismal state: the Big Chill.

The second of which is similar to the first, except in this theory, there is enough matter that gravity slowly stops the expansion of the universe, and instead starts pulling it all together. This gradually means that all matter eventually collides into each other, either squeezing together into a black hole, or even starting another Big Bang. This theory is the Big Crunch.

The third is the theory of the big rip, in which the expansion of the universe keeps accelerating, which is caused by dark energy. This keeps on going without limit, until eventually, dark energy completely overpowers other forces keeping the universe together, and atoms themselves are ripped apart.

Out of the three, the Big Crunch has already been ruled out as impossible, due to the existence of dark energy which pushes galaxies apart. Out of the other two, physicists have ruled the Big Chill to be the most likely to happen, although they have not determined whether any of them are even possible or not. However, as science continues to make new ground breaking discoveries on a daily basis, it is likely that humanity will have its answer in the future.

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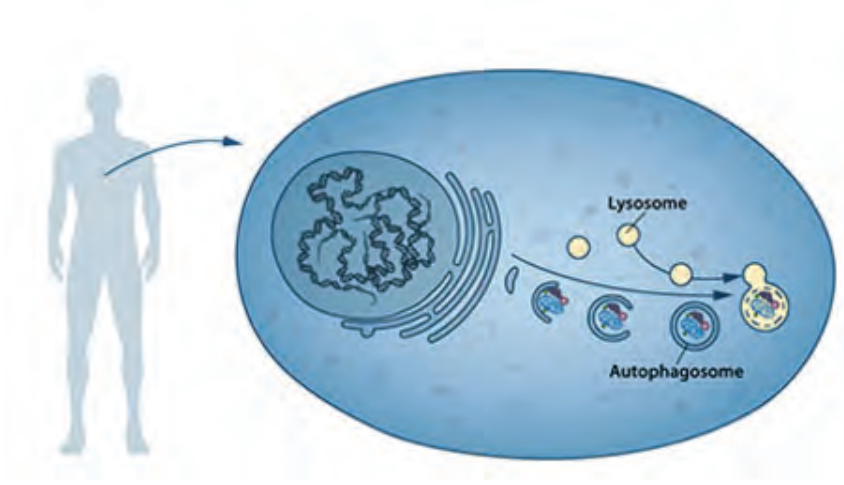
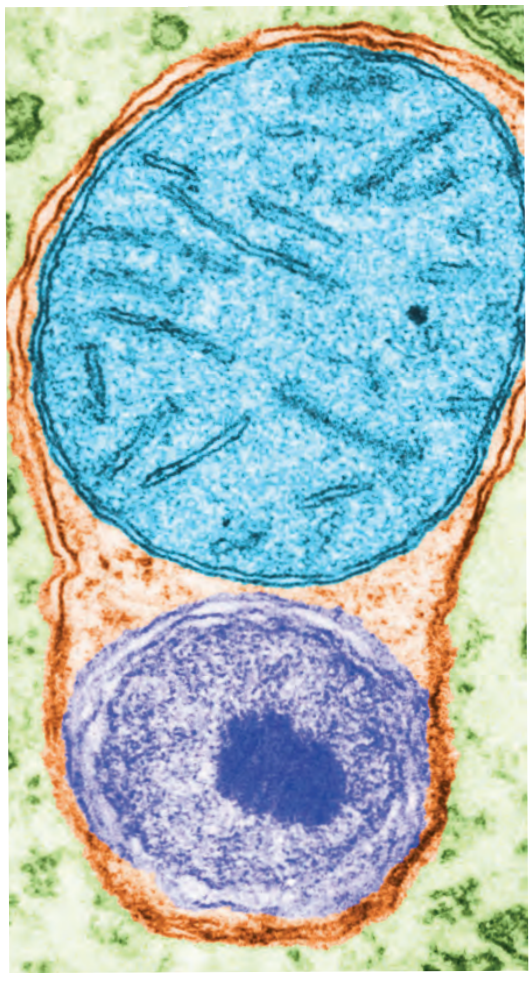
Can Diseases be Cured by 'Recycling' Cell Contents?

Miyu Terashima Year 11



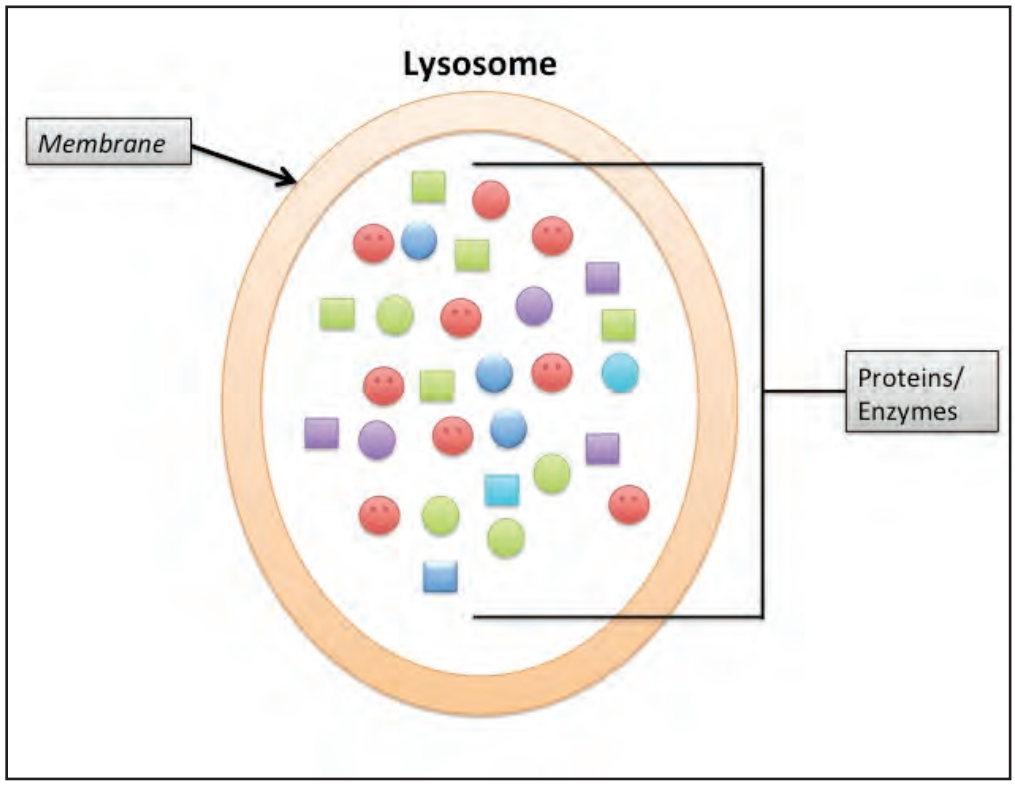


Diseases constantly create numerous problems for us humans, such as stress and pain. There are a variety of diseases in the world, in which some may take a very long period to be cured. Many of the population are suffering under these diseases as getting rid of them can take up a lot of stress and time. Some major diseases that last for a long term includes cancer, diabetes, Parkinson's and Alzheimer's. While diseases are currently progressing, it is essential for doctors to find an easier lead to cure these diseases more efficiently.

Recently, it has been discovered that the process of autophagy can find alternative ways to cure these diseases which is a process that is done within cells. Cells are the basis of every living organism and has a main purpose to survive. Although they are essential to keep our lives running, they cannot continue to survive without a constant supply of nutrients and therefore in comes the help of autophagy. Autophagy is sometimes called as 'self-cleaning' or 'self-eating' and this means that the body makes use gets rid of unwanted substances. Cells simply go hunt for any bits and pieces from dead cells and break down and 'recycle' its contents to reuse them. This results in providing more energy and fuel, creating new parts for the cell itself. Cells can rely on autophagy whenever the cell is containing harmful substances and replace them with beneficial ones instead to decrease possible health risks. Autophagy usually occurs when a living organism is running low on nutrients so that cells can maintain their original purpose.

Many scientists began to pay more attention to autophagy last year, when Yoshinori Ohsumi from the Tokyo Institute of Technology won the 2016 Nobel Prize in Physiology or medicine for his research in the mechanisms of autophagy. As autophagy helps the body to get rid of harmful organelles, it also helps the body to adapt to its new environment by constantly recycling molecules within cells. He had tested this through cultured yeast that lacked enzymes that would normally be used to break down substances easily in the vacuole. After setting up an environment in which the cultured cells inside the yeast would starve. During his experiment while the yeast cells had starved, he managed to observe autophagosomes (a sac containing fluid that is released during autophagy) accumulating in the vacuole within cells. This means that autophagy was taking place while the yeast cells were low on nutrients and autophagy was helping the cells to survive even when the cells are starving. After his discovery, it is thought that autophagy is an important stage to prevent cells from aging and therefore reducing the causes of diseases, especially diabetes and Parkinson's.

To go into more depth, autophagy gains the help of the organelles that are in our body that are filled with destructive acidic enzymes called lysosomes. Lysosomes were first discovered by a Belgian scientist called Christian de Duve in the 1960's. These little digestion machines help to destroy any substances from dead cells in our body that are unwanted. It first fuses into the cells and once the lysosomes are inside, they attach themselves to the cell and release their enzymes to digest any glucose or proteins that are very nutritious for cells. Lysosomes even digest oily droplets to release energy for cells to construct new molecules, 'recycling' the cell components. This can especially be activated when your body is low on nutrients for example a time between lunch and dinner where you don't eat any snacks in between.



This process is important in understanding how cells work and how they can be used to treat damaging diseases that result from the aging of organisms. Recently, additional experiments were held in Japan to test the effect of lysosomes' existence in living organisms. Mice were engineered from birth so that they could not use lysosomes and results showed that the newborn mice died of starvation immediately. This experiment showed how autophagy is crucial in our lives - if autophagy is not working efficient enough within our bodies, each of our cells would remain unhealthy while containing impure substances that would increase health risks. Moreover, Dr. Ana Maria Cuervo, a molecular biologist at Albert Einstein College of Medicine has also contributed with experimenting autophagy with her colleagues by engineering mice to have increased numbers of portals on the surface of their lysosomes. They observed how livers work better with the engineered lysosomes that had more portals on their surfaces which lead to a conclusion that the more cells perform autophagy and 'recycle' their contents, the quicker the cells can get rid of unwanted substances and organs or tissues can serve more efficiently for their given purpose. With all the experiments that has been tested for the effects of autophagy, this process has been recognised as a method to prevent metabolic dysfunction like obesity and diabetes.

Autophagy can play a role in controlling immunity within our bodies and can also prevent inflammation from happening. By doing so, this process can lead to becoming a key to slow down our aging process. The discovery of autophagy is crucial for us to understand as it is one of the fundamental importance in medicine. If we have never known of autophagy, we may not have been able to overcome certain cases of diseases or deaths. Currently, there is a growing scientific need to understand more of the autophagy process by identifying how its benefits could moreover be an advantage to us humans. In the future, diseases may be easily cured by replacing the unwanted substances within cells with more useful contents such as protein and preventing causes that may stimulate diseases.

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Attack ByAlien Species

Wendy Leung Year 11

Deadly insectoid beings fly down from space and strip the Earth bare of its resources, killing everything they come into contact with. We've seen those kind of movies. It can be seen as an (over exaggerated) example of the effects of "Alien Species". Alien species, aka non-native or introduced species, can be defined as a species introduced outside its natural habitat by human action (both intentional and unintentional), and the species is able to thrive in its new environment. This often causes long term negative impacts on the environment and human economy, after all, once a species is thriving, it is difficult to remove them. This article with briefly cover several cases of alien species and their effects.

Hong Kong

A large amount of Hong Kong's biodiversity is non-native. A third of plants are non-native and thriving in Hong Kong's countryside. Most introduced species do little harm and can even be beneficial to Hong Kong's urban lifestyle, but there is a small proportion that devastates local ecosystems.

I'm sure that a large number of families have (or had) an American Red-eared Slider Turtle for a pet. My two pet turtles have certainly entertained me for a very long time (until they passed away from sickness). These turtles are often bought at a cheap price when they are the size of a coin, and grow to the size of a dinner plate and become increasingly difficult to feed, at which point most city owners tire of them, thus releasing them into freshwater ponds or reservoirs. As they are aggressive predators, they compete with local species, such as the Reeves' Turtle, for food and territory and have become the most common turtle in Hong Kong. They are also prone to fungal infections and are carriers of salmonella.

We see this particular plant everywhere in Hong Kong: along the roads, around villages, in parks and abandoned fields. Mikania is a perennial herbaceous vine from South and Central America. They climb up plants to reach for sunlight, eventually blocking out the sun with its leaves, killing their "host plants". They also spread rapidly during spring and summer, due to their ability to produce a large number of seeds and rooting in a short amount of time. The Agriculture, Fisheries and Conservation Department (AFCD) are currently working to reduce the rate of invasion (albeit with little success and many implications) using various methods such as physically clearing it, herbicide and managing areas to be shadier so mikania cannot thrive as well. It is deemed impossible to remove mikania completely from Hong Kong so the current focus is on managing it so it doesn't reach more important ecological areas.

Grey Squirrels Vs Red Squirrels

This is probably one of the most popular topics when it comes to alien species worldwide, after all, who can resist the adorable bright-eyed, bushy-tailed rodent?

Grey squirrels were first introduced to England from North America in 1876 as a decorative addition to stately homes. They were continually introduced until 1930, due to their attractive appearance. However, because the grey squirrels have adapted and outcompete the red squirrels, the red squirrel population is declining. It is predicted that grey squirrels may replace red squirrels within 15 years.

So why is this happening? An adult grey squirrel is twice as large as an adult red squirrel and carry four times more fat, meaning that they have a higher daily food requirement. In consequence, they consume most of the food source that they share with the red squirrels. They can consume tannin, a chemical found in unripe acorns, allowing them to eat all of the acorns before the red squirrels can eat them. It is also proven that they are also better able to extract energy and protein from their food, storing energy to survive the winter. Thus, female red squirrels and they are unable to reproduce. Young red squirrels also find it hard to survive with the decreasing

amount of food. The survival rate of red squirrel young during the tough winter has dropped from 50% to 17%.

Grey squirrels are also carriers of squirrel pox virus, which is fatal to red squirrels. A single infected grey squirrel can infect an entire colony of red squirrels, consequently increasing the death rate. Grey squirrels can live at higher densities, increasing chance of contact between the two species. It is also observed that grey squirrels raid seed stores, transmitting the virus at the locations. The decline in red squirrel population is 17-25 times faster when infected with the virus.

Several methods were used to attempt to control the grey squirrel population with little success. Initially, the import of grey squirrels are banned in 1938. Some of the more successful methods were limiting the amount of oak in conifer forests, making it less attractive to grey squirrels. To combat the squirrel pox virus, a vaccine is being developed. It is also found that the number of grey squirrels carrying the virus is decreasing. There is also the issue of people having emotional attachment to the grey squirrel, hindering “culling” or “pest eradication” which is also a method (albeit proven unsuccessful).

Australian Cane Toad

This is another famous, and slightly disturbing, case. The cane toads were originally introduced as a form of biological control to eat a plague of sugar-cane eating beetles, however, not only did they ignore the beetles, they multiplied, and became pests themselves. The original 102 toads soared to 1.5 billion as they mate year round and females laying 30,000 eggs each time (in any type of water, fresh, salt, still and moving). As they are non-native, there are no natural predators or diseases to combat its population.

Due to their large population their rate of invasion extremely high, having already conquered more than one million square kilometers of the country. They also produce toxins, poisoning other animals (including top predators) that consume them. This causes trophic unbalance, and prey of the poisoned predators thrive as well. It has been shown that the decrease in quoll numbers is directly linked to the toads. Due to their sheer numbers, they consume large amounts of food, outcompeting and leaving none for native frogs and toads.

Most methods such as genetic modification, pesticides and culling were ineffective. Even when hundreds of toads are killed, thousands take their place. 17 million USD has already been spent on toad control, which was shown to be temporary. The focus has changed from trying to eradicate them to reducing the impact they have on the local ecology. The government has prioritised scientific research on understanding the toads’ impact on local biodiversity and minimizing their impact. Another perspective taken on by Team BUFO (research group from the University of Sydney) is to change the ability of native species to deal with the toads.

Conclusion

We should learn from our past experiences and increase control on biological objects to prevent unintentional introduction from happening. If introducing on purpose, the potential impacts should be reviewed and perhaps try introducing them in a controlled environment to observe the effects. While extinction is forever, introduction is also forever. Once it has taken ground in its new environment (which may possibly be even better for it than where it originally came from), it is impossible to stop its invasion, and unlike in movies, we have no protagonist to stop them.

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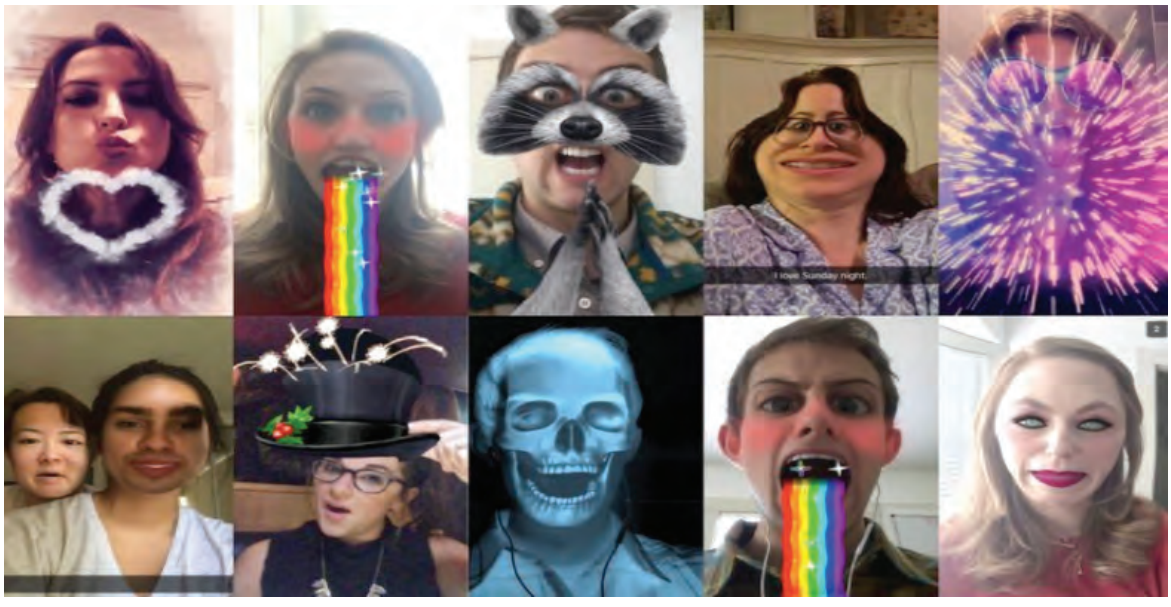
Looking Through the Glass:

Augmented Reality in Snapchat

Arushi Gupta Year 12



One of the most exciting features of popular disappearing photo and video sharing service Snapchat, is its incredible ‘Snapchat Lenses’. Lenses are masks, designs and graphics that are digitally superimposed on your face creating an entertaining illusion you can share with your friends. But what is the science behind it? Without our even realising it, Snapchat has introduced us to the fascinating world of Augmented Reality.In simple terms, Augmented Reality (AR) refers to a combination of real and virtual (computer-generated) worlds. Given a real subject, captured on video or camera, the technology 'augments' (= adds to) that real-world image with extra layers of digital information.

Technology behind AR

The technology behind AR is very advanced as it is able to deal with new information immediately and superimpose it with the physical real-world environment. To understand better how exactly AR works- there are 4 tasks carried out by the system: Scene capture, Scene Identification, Scene Processing and Visualization of the augmented scene.

Scene Capture

This can be done by devices such as computers with webcams, mobile phones and tablets with cameras, video cameras and head mounted displays. The quality of the camera and lighting conditions can affect the quality of the scene captured. For example, while using snapchat app on your mobile phone, the phone’s camera is used to capture the image.

Scene Identification

There are some scene identification techniques which are either Marker-based or Markerless. Marker based- Markers could be like QR codes (Quick Response code which is a machine readable barcode) which may be placed as part of the scene. For example a QR code could be placed near a picture in a museum . Once the scene is captured which contains the QR code, the code links to a web address, and the device’s browser looks up the appropriate web page with further information, which in this case could be more details about the artist of the picture. These markers are called “added reference points” which have been placed specially as part of a scene so that an AR system can add information about the scene when it is viewed. AR systems can be designed to read all kinds of other markers (or fiducial markers) and barcodes.

Markerless- This type of Scene Identification can be of three types:
a. Image Recognition: You could point your phone at each picture or exhibit and have some kind of pattern recognition or feature-detection system try to identify it. In a museum, this would take the form of identifying a painting if you point your phone camera at it. In Snapchat, the software recognizes the image of our face by identifying features such as our eyes,nose,mouth etc and is able to apply entertaining masks over them.
b. Geopositioning: This technique uses GPS (Global Positioning System) of the camera to identify where the image has been captured. For eg. in Snapchat special Geo-Filters get activated depending on where the picture/video is taken by calculating the latitude and longitude of the photographer’s position. If you are taking a picture in

New York for instance, with the help of the phone's GPS the scene identification part of AR will be able to recognise and a Geo-Filter related to New York will be shown over your image.
c. Hybrid: This technique makes use of a mixture of image recognition and geopositioning.

Screen Processing and Visualisation

When the scene is captured and identified, the process of mixing real scenes with virtual information begins. Basically, this process superimposes any type of digital information (usually audio and video) onto the real scene. There are 2D and 3D graphical libraries that permit mixing of real and virtual information. For example OpenGL, Java 3D and NokiaCV are popular graphical libraries used in computer application development.

At the end, the system produces the combined image of the real-time object and the augmented information obtained after processing. This Augmented Reality image is then presented to the user.

Other Applications

Besides used for entertainment as in Snapchat, the applications for AR are increasing continuously. In the medical field, AR spectacles can be used by a blind person. The AR spectacles are fixed with a camera and an earphone which gives an audio commentary to the blind person of the scene around him. The popular game "Pokemon Go" is another example of augmented reality where players have to find images of Pokemon through their phone or tablet's camera by pointing them towards specific locations. Similarly for students, new information would be at our fingertips in a fun and interactive way.

Recent Advances

Recently, Snapchat created Snapchat Glasses which can be worn over the eyes and provides the same features of the app used on glasses instead of a smartphone. Snapchat has also recently acquired an Israeli augmented reality startup Cimagine Media, indicating that the company intends to make great leaps into the field of Augmented Reality.

AR is a constantly evolving technology that will soon be more accessible to us in the future and will become a complementary part of our lives.

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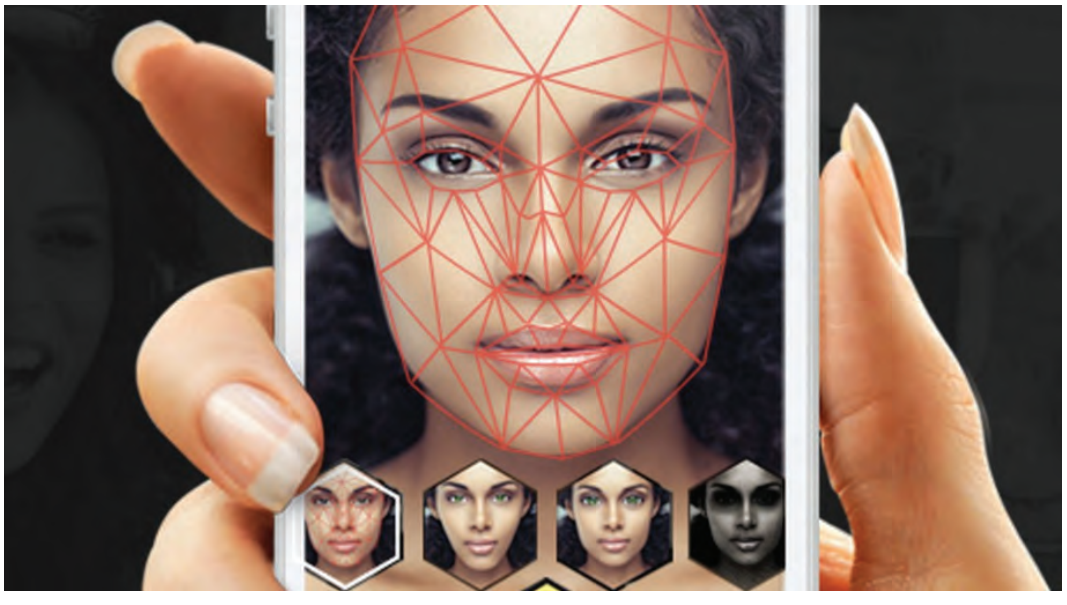


Mirror Neurons: Gateway to Empathy

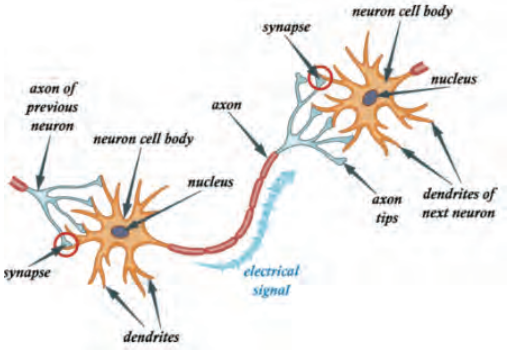
Olivia Bray Year 12

What are Mirror Neurons?

Mirror neurons are neurons in your brain that fire when you see something happen to someone or when someone performs an action. Mirror neurons are why you flinch when ou unexpectedly see someone getting punched, or why your hands may twitch if you see someone grab an object. These neurons make you experience the same sensations as the person who performed the action in the first place, so it's as if you were punched in the face or grabbed the object.

Mirror neurons were actually discovered accidentally. In the 1990s, Italian researchers hooked macaques up to electrodes so that their brain activity could be monitored. One day, when a researcher reached out to grab some food during his lunchbreak, he noticed that one of the monkeys was watching him and neurons were activated in his prefrontal cortex, the area of the brain that controls movement. The brain activity was exactly as if the macaque had grabbed the food himself.

This led to further experimentation in 1995, where a study found that when people watched someone grabbing an object, their hand muscles instinctively tensed as if in preparation for grabbing that object themselves, which proved the existence of mirror neurons.

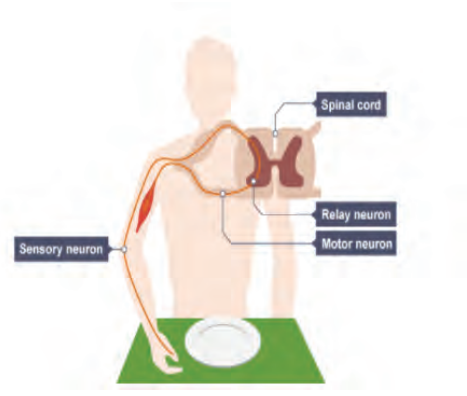


How do Mirror Neurons work?

To understand how mirror neurons work, we must first understand the general structure of neurons.

There are three main parts of a neuron: the dendrites that detect electrical messages, the axon that messages travel along, and the synapses that let messages be passed on to other neurons.

There are also three different types of neurons. Sensory neurons detect stimuli from outside the body and create messages conveying information from the outside world to the relay neurons that take that information to the brain or spinal cord. Once the nervous system decides on an appropriate response to the stimulus, it sends this response in an electrical message to a motor neuron that can activate the right muscles to respond to the stimulus.



Mirror neurons work in the same way. Sensory neurons in the eyes transmit electrical messages conveying what the eyes are seeing, these messages get sent to the brain, and sometimes they result in motor neuron action (which is why we have reflexes).The memory of that message and the response is imprinted in the brain through neuron action, and the neuron response is replicated whenever someone remembers that stimulus or sees it happening again. The memory pattern is in the same location in the brain as where the neurons would have fired if you'd experienced that action yourself, and the effect is particularly noticeable if the experience you are recalling or seeing is particularly noteworthy or emotionally resonant (such as watching someone hurt themselves).

Why are Mirror Neurons important?

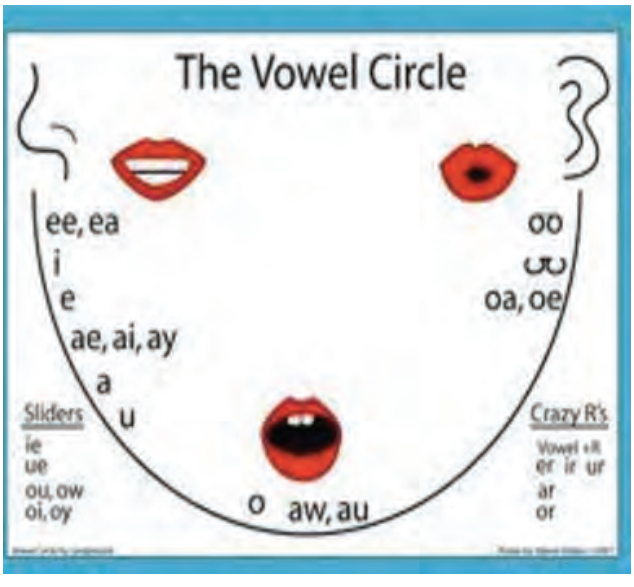
Doctor V. S. Ramachandran, who was a pioneer in researching mirror neurons, once said that mirror neurons would do for psychology what DNA did for biology. Mirror neurons don't just allow people's minds to replicate actions, but also the intentions and emotions behind the actions, which means that mirror neurons have become invaluable in studying human behavior. Without mirror neurons, we wouldn't have:

Empathy

Theory of mind is a knowledge that almost everyone shares: the knowledge that other people have their own thoughts and feelings. This concept develops at around the age of 3 or 4, which is why young children are completely self-centered: they literally can't understand that other people have minds too. Mirror neurons are essential in developing theory of mind because they allow you to literally feel some of what other people feel, which leads to the understanding that other people experience the same emotions and do similar things for similar reasons to you. Once theory of mind develops, this can lead to more complex empathy. Sometimes mirror neurons allow you to use empathy on a more tangible level, such as understanding physical pain, and sometimes you can also empathize with mental states, such as happiness.

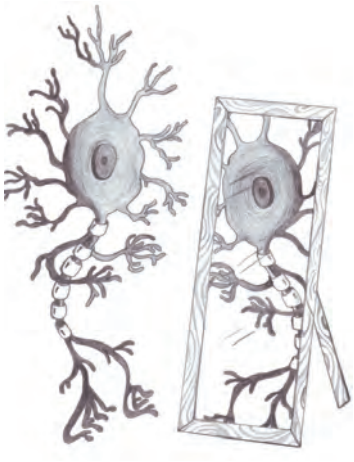
Socializing

One reason that mirror neurons aid socializing is because of empathy. For example, if you see a friend hunched over in a corner and crying, you'll be able to work out that they must be sad about something, and then you can start to logically deduce how you should respond to them and what they might be upset about. Once mirror neurons help you understand basic emotions, you can work out how to respond when you see those emotions in other people. Another reason mirror neurons are helpful is because 60 to 90 percent of our communication is non-verbal. It's less about words and more about body language, tone of voice and gesture. Watching people's actions and non-verbal cues causes the same actions to be mimicked in your mind so you can work out the intentions and emotions behind them. This is why if you want to get someone on your good side, you should subtly imitate their body language while talking to them. Their mirror neurons will notice that and realize that you understand what they are talking about.



Language

Mirror neurons are also important in verbal language. Not only are there more mirror neurons in the left hemisphere (the more logical half) of the brain, and in Broca's area (the part of the brain that controls speech and language), but other people's vocalizations activate mirror neuron systems. This explains a lot about syntax: why certain sounds in certain letters have specific emotional connotations.



What happens when Mirror Neurons don't work properly?

Nowadays, many studies on mirror neurons focus on people who have fewer mirror neurons than they should, or a mirror neuron system that is damaged. Research on the conditions mirror neuron damage causes may lead to better options for therapy and treatment of certain mental disorders in the future, such as:

- Autism – symptoms vary depending on how severe the condition is, but autism often causes language delay, lack of empathy and difficulty in learning social cues

-Schizophrenia – symptoms vary, but in many cases this disorder causes a breakdown in the understanding and use of language – a 2014 study found that malfunctioning mirror neurons mean that many schizophrenics lose the ability to imitate other people's actions

-Narcissistic personality disorder – characterized by extreme arrogance and disregard for other people (lacking a theory of mind)

-Psychopathy – many people believe that psychopaths have no capacity for empathy, but a 2013 study on psychopathic criminals found that psychopaths can activate and switch of their mirror neuron systems at will

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Turbulent mind, turbulent flow:

Post-impressionism and Physics

Prerna Roy Year 12

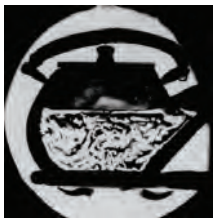
Millions of people have seen The Starry Night, yet the underlying physics and mathematics of the artwork are unknown to many. Painted by Vincent Van Gogh in June 1889, The Starry Night shows a phenomenon that many scientists and mathematicians are still baffled by: turbulent flow. The Starry Night is also an example of luminance.

Impressionist paintings such as 'The Starry Night' have shown to capture the motion of light - something that is not well documented in physics, nor is easy to calculate.

Turbulent flow and luminance are two different concepts that have worked together to make Van Gogh's beautiful painting, The Starry Night. Turbulent flow occurs in fluids only - liquids and gases - and the motion of these fluids are irregular, unpredictable and often described as chaotic. In The Starry Night, turbulent flow is seen from the quick, hard strokes in the painting. Turbulent flow is difficult to describe, and in short is usually described using 'eddies'. Big eddies will transfer their energy to smaller eddies, and the process continues.
On the other hand, luminance is the intensity of light emitted from a surface in a given direction - in terms of Van Gogh's artwork, the intensity of light from the colours on the canvas. Luminance can briefly be explained how 'strongly' light is given off from another surface in a specific direction. The more intense the light given off is, the higher its luminance.

Our brains process the motion of turbulent flow and luminance in two different areas: the more primitive visual cortex that does not see colour, but sees contrast and light will merge the colours of two entirely different coloured areas if they have the same luminance. Conversely, in the primate subdivision of the brain, the contrasting, differently coloured areas will be viewed without blending them. When these two processes occur at once it creates the sensation of light moving and radiating - this is how Impressionist work such as The Starry Night looks as though it is glowing. This is especially seen in the upper portion of the painting, where similar luminance between the yellows, whites and blues makes the sky appear more vibrant, hence giving the phenomenon of stars twinkling in the painting.

Decades after the painting was made, a Russian mathematician named Andrey Kolmogorov, had proposed an attempted mathematical equation to explain energy in a turbulent fluid. Afterwards, many other mathematicians and scientists alike tested this equation and found that Kolmogorov was extremely close to finding out how turbulent flow works. Mexican physicist Jose Luis Aragon and his team were inspired by a comparison between a picture eddies of gas and dust around a star from NASA's Hubble Space Telescope and The Starry Night. They investigated many of Van Gogh's paintings to see whether mathematical turbulence, as proposed by Kolmogorov, was reminiscent in his work. They first digitised the paintings, and afterwards take measurements of the variation of brightness between any two pixels. It was found that They Starry Night had structure patterns of turbulent flow. The measurements taken from The Starry Night were impressively close to Kolmogorov's equation.



Interestingly enough, many paintings from Van Gogh's time in the Saint Paul asylum in Saint Rémy had measurements eerily close to Kolmogorov's equation, although paintings from the calmer period of his life showed no such turbulence. Paintings such as Road with Cypress and Star and Wheat Field with Crows both showed structures of mathematically calculated turbulent flow. As well as this, impressionist works by other artists did not come close to the fluid turbulence Van Gogh had achieved - making him truly one of a kind.

What makes Van Gogh's work so special is that most examples of naturally-occurring turbulent flow vanish within a few seconds or minutes - the movement of smoke particles leaving a cigarette, the air currents within our atmosphere and even the motion of boiling water inside a kettle. It is difficult to calculate turbulence because the nature of it requires it to constantly change its movement in both direction and speed - there is no easy way to measure the relationship between these ever-changing properties. Van Gogh's work almost captures turbulent flow as a still, after all, it did match up to the approximation made by Kolmogorov.

Overall, Van Gogh's ability to paint to such a high degree of accuracy to Kolmogorov's equation shows a beauty in science that is often forgotten behind all the formulas, equations and laws. Furthermore, the fact he painted these works whilst being in a turbulent mind of his own certainly shows an unappreciated impressiveness, as he was almost unheard of during his lifetime. His works have not only had an impact on art everywhere, but also has intrigued the scientific community with his wonderful, science-filled and fascinating work.
□

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‘One from outside, two from inside’ :

CHIMERA, a significant milestone in Genetic science.

Disha Mehta Year 12

A big giant crab, as big as a tall building, crawling and crushing everything in its way in seconds….. buildings, bridges, out it reaches into the sea to grab the cruise liner full of terrified people ….. Superman, Batman, Hulk and our trusty mutant Ninja turtles magically swoop in and crack the evil crab into two to finally save the city! A scene from the next Marvel and DC comic collaboration? …. NOT REALLY. This could be true, if genetic science is to be believed. Genetic Mutation is not fiction; it is real, bone chillingly real. Welcome to the world of Chimera!

From biological sciences, we always understood that our genome is at the heart of our identity. Every individual has a distinctive identity of oneself through the DNA which he/she has inherited from his/her parents. DNA, or deoxyribonucleic acid, is the hereditary material in every cell of all living organisms. That means every cell will have the same DNA. However, this prodigious fact was challenged when a strange case happened in 1953 in northern England. This shook the entire genetic research. This case study inspired me to write this paper and to get a comprehensive understanding of a significant milestone in genetic science known as Chimera.

Discovery of Human Chimera

Till date, medical science has unexpectedly discovered only about 100 cases of human chimeras. My inquisitiveness in genetic science led me to research further to find out about the details of the first case of human chimera. In 1953, a woman Mrs. Mck, in northern England surprised the world when it was known that she had a combination of more than one blood type: 61% O group cells and 39% A group cells. This was detected when once she donated her blood as a kind gesture.

The blood sample results revealed two separate blood types, which puzzled the Lab in charge to a great extent. Immediately, he sent the specimen to Robert Race and Ruth Sanger, specialists at the Medical Research Council Blood Group Unit in London.

Race investigated deeply to trace any previous connections which could help to untangle this mystery. He came across an article about fraternal twin cows that not only carried two separate blood types but also had each other’s blood in their separate bodies. Race proposed a hypothesis, that Mrs. McK must have been a twin, and possibly her twin’s blood had infused into her body during gestation where it continued to circulate decades later.

The hypothesis was proved correct when Mrs. Mck confirmed that she had indeed been a twin. In particular, she must have absorbed her twin while still in utero which is generally known as ‘Undetectable condition’ of human blood chimera. Before Mrs. McK, genetic science had glances of chimera being present in lesser mammals and some plants. However finding traces of chimera in humans was a huge turning point in research of genetics.

Just imagine, how frustrating it could be for us when we discover that one of our two children was genetically not ours. One can go into catastrophic depression and the worst comes when you are expected to fight a battle against science to prove that the child is yours. Your heart feels terrible and extremely unfortunate. Crazily all the questions arising in our mind begins with “How”, or “Why” and not “Who?” The same grievous feeling happened with a woman from Boston Karen Keegan, aged 52. Something appalling was known which shook her motherhood completely. Some preliminary tests were done before her kidney transplant from her donor sons. It was revealed that she was not the biological mother of her two sons. Human errors can happen, hence to eliminate any such chances new DNA tests were ordered from different labs. Every single moment was excruciating for her, but the results were again the same. The three children carried one cell copy that matched their father’s, however only one child carried a second copy that matched Karen’s. Explicitly, Karen had different set of genes in her blood cells than her ovaries. More investigations revealed she was also a twin. The equation ascertains that her children were physically hers but genetically of her twin sister who was never born. These case studies enlightened a new appreciation for the phenomenon of genetic chimerism— ‘When an individual carries two or more genetically distinct cell lines in different parts of his/her body’. ‘One from outside, two from inside’ is the gist which I comprehend from these cases

Types of Chimera

In Greek mythology, the chimera was a creature with the head of the lion, the body of a goat and tail of a serpent. Referring to medical science, a genetic chimerism is a single organism composed of cells from two or more ‘individuals. While most individuals have only two sets of DNA — one inherited from each parent — chimeras are blessed with an extra DNA. Chimerism can be classified under these categories

Natural chimerism - It is observed when a fetus absorbs some of the cells of its fraternal twin, who does not survive in early pregnancy time.

This can be related with the phenomenon known as 'Vanishing Twin' when the remains of this twin get absorbed into the remaining healthy sibling. Barry Starr, a geneticist at Stanford stated that artificial fertility treatments are much more likely to lead to multiple births, which in turn increases to produce more people with chimerism.
Artificial chimerism- A bone marrow transplant from another person can also result into chimera. This happens when the stem cells present in the bone marrow starts developing into red blood cells that are genetically identical to those of the donor. However, these cells are different than the original other cells of the body. Examples known are - chimeric Monkeys of 2012 made from multiple embryos, the pig with human flowing blood created at the Mayo clinic in 2004 etc.
Transplacental chimerism – This includes cases where during pregnancy period, there are some cells exchanged between the mother and her male foetus which remains in mother's blood for decades. A small fraction of foetal cells with Y chromosomes could persist in mother's body.
Tetragametic chimerism- At times, a female embryo gets merged with the male embryo. Such chimeras will possess ambiguous genes and show both male and female markers on their body. Such occurrences are more probable to be found in In Vitro fertilization (IVF) cases where more than one fertilized egg is placed in the uterus for a better success rate.
Science is still unsure to consider human chimerism condition as physical abnormalities. One can observe phenotype differences in eye and hair colors, checkered patterns on skin or missing extraneous sexual organs. A strange case happened in In 1998 at University of Edinburgh where a male patient had complaints about an undescended left testicle. On further investigation they found an ovary and a fallopian tube in the male patient. Dizzying, isn't it? But he is also one of the human chimeras.

Effects of Discovering Chimera

After understanding about chimerism, I now challenge to reconsider the blind faith entrusted into results of DNA testing. Can forensic science believe on the evidences from DNA testing as the sole source?

There is a strong possibility that the criminal or the victim could be a chimera. Medical scientists are doing researches to create a platform where chimeras could help in improving the existing organ transplant process for patients. The phenomenal fact is that chimeras are blessed with great immunological tolerance to at least two different cells. However, the disadvantage also prevails that the presence of foreign cells in the bodies of chimeras can also cause the growth of various types of autoimmune diseases such as Diabetes or lupus. The field of research in genetics is endless and like other discoveries, chimerism could be considered ironic as a double edged knife that can offer great benefit to medicine and also pose a great harm to humanity. Substantially we need to penetrate within the mechanisms that allow the immune system to accept genetically distinct cells within one body. This could lead to new therapies for cancer and autoimmune disorders.
A revolution of producing animal chimeras is sweeping fast across the genetic world. "Geep" chimera a combination of goat and sheep cells and a 'Human– mouse' chimera have been produced by well known scientists. Medical scientists have succeeded in producing human embryos to be inserted in animal organs. Nevertheless, many ethical and religious questions have emerged from these discoveries. Science never ceases to amaze me but here, I question the existence of spiritual and psychological ideologies associated with birth where I believe in the existence of soul "Can the soul which vanished effect the one which is surviving? ", "Can we associate chimeras with split personalities or Multiple disorder diseases? " Well, I leave it to science to weave this yarn for me.

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I think, therefore, I am concious

Thomas Yik Year 12

Consciousness is difficult to define, however it can be broadly described as the experience of being inside your head: the actions of seeing, hearing, smelling, touching, and tasting the environment around you. However, what exactly causes consciousness? We can understand how memories are stored, how our emotions affect our actions on a neurological level and how our brain learns; yet we still cannot fully understand the great mystery of consciousness.

“Why aren’t we just robots, who process all these inputs, produce all that output without experiencing the inner movie (consciousness) at all?” David Chalmers, TED talk. David Chalmers is cognitive scientist specialising in the philosophy of mind and language.

Currently there are two notable theories for consciousness, the Integrated Information theory and Global Workspace theory.

Integrated Information theory and Global Workspace theory

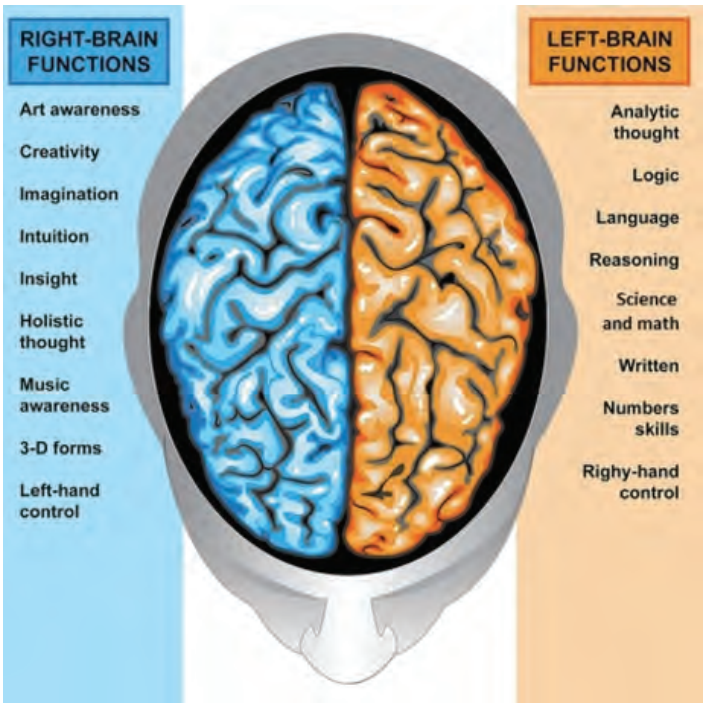
The Integrated Information theory is the idea that consciousness “represents the integration of a wide variety of information”. Tanya Lewis, Live Science. To understand this we first need to explain what integration of information really is. The human brain has really well developed cerebrum compared to other animals; this is the part of your brain where all voluntary actions and thoughts are made. (This excludes actions you may do subconsciously like breathing and the control of your heart beat) The brain is constantly bombarded with input information from all your senses, while at the same time performing large amounts of cognitive processes, which all happen in the cerebrum. The theory believes that the cerebrum is so well connected and developed that it eventually creates the phenomenon of consciousness.

The Global Workspace theory is based on an idea of a brain ‘blackboard’. Developed by Bernard Baars, the ‘blackboard’ is the centralised system of the brain. (A brain in a brain?) Consciousness is what brings all of the brain processes together for cognition and decision and execution.

These two theories are not mutually exclusive, and can exist with one another. While one theory tries to explain what gives rise to consciousness, the other tries to explain how it functions. Admittedly they are both flawed in that they provide a limited scientific explanation for why consciousness even exists. So what can science tell us about consciousness?

Not much really. That is not to say scientific research on consciousness is useless in any way, in fact this research has led us to better understand the specific functions of each part of our brain, and the correlations in brain activity with thought processes and actions. For example, we know that the left hemisphere of the brain is responsible for logical processes like science (ohhh like right now) and maths, while the right hemisphere is responsible for more creative thought processes and intuition. Apart from that, psychologists can even discover the difference in neural patterns between psychopaths and ‘normal’ humans. Yet, despite all of this scientific knowledge, we cannot draw the link between these nerve impulses and the subjective state of consciousness.

Some people have even claimed that consciousness cannot be proved by science. They claim that science is objective and requires physical proofs, while consciousness is itself a subjective experience. How can you objectively prove something that is subjective? Presently, the only way to prove consciousness is through philosophy.



Proving consciousness

Je pense donc je suis. This is a philosophical proposition by René Descartes, a famous 17th century French philosopher, which translates into "I think, therefore I am." Descartes believed that there is no doubt of your own existence if you are capable of doubting it, and this principle served as proof of the existence of one's own consciousness.

Another conclusion that can be drawn from this philosophy is that you are never absolutely certain of other people's consciousness, because you cannot truly prove that they are actually conscious instead of a simulation of consciousness. (A very unsettling thought indeed).

While so far science cannot prove consciousness, it can prove that it is not limited to a particular region of the brain. Studies on patients who have had hemispherectomy (a rare procedure where half of a patient's brain is removed), have retained most if not all of their intellect and cognitive ability after post-surgical therapy no matter which side of the brain is removed.

Animal consciousness

We have usually considered consciousness to be unique for the human species, but how about other organisms? Plants, fungi, bacteria, viruses and other single-cellular organisms can be immediately dismissed as they lack a brain, which is the basis of consciousness (except in karma and reincarnation and other beliefs). What about other animals like dogs, elephants and dolphins, which have repeatedly demonstrated the capability of emotion and cognitive function? Their brain structure is similar to humans', so are they capable of basic consciousness? Perhaps. Studies have shown that dogs exhibit an intelligence of a three to five-year-old human. Flashback to when you were three to five years old, you probably were conscious by then and already have memories of your experiences at that point.

Maybe our technology is still not advanced enough to solve this phenomenon, or maybe our intellect is not developed enough to comprehend its own existence, or maybe it's something else. Currently, the truth is nothing is certain in the science of consciousness, but hopefully time will prove us wrong.

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How Does Chemistry Change the World?

Joe Reed Year 12

Look around. Everything that you see can somewhat be attributed to chemistry in some way, shape or form. Chemistry is the most important subject because the whole world, and everything thing comprising of it, is made out of matter. Through chemistry, we can learn the reasons for why things happen, and further predict what will happen. Without the study of chemistry, we would still be living in the dark ages, without the development of medicine our average life expectancy would still be 35 as opposed to the 71.4 years it is now. All the music that you listen to, all the television that you watch, all of the food that you drink, chemistry is the way that we as humans can understand all of it, and the way we can innovate and create new ideas that we can use everyday and incorporate into our everyday life.

It was the 17th century, and modern chemistry is developing at a rapid rate. The 17th century, however, was not a pleasant time to live due to the many deadly and infectious diseases that ran rampant through the streets. Luckily, the development of modern chemistry led to the understanding of medicine. The understanding of the chemisty of medicine allowed for the development of the vaccinations and necessary chemicals in order to fight diseases such as: the bubonic plague, measles, smallpox, tetanus, mumps and polio. Without chemistry, these medicines would still be huge problems in our societies, with deaths easily reaching the millions.
Not only would diseases be nearly incurable, but food and waterborne sickness would be at an all time high. The introduction of methods such as pasteurization, in 1864, allowed for chemists and biologists to heat food and drink to a suitable temperature in order to kill the microbes on said foods. This is essential in the modern world as many foods are unable to be kept outside the fridge, such as most dairy products. Not only is pasteurisation the way to preserve dairy, it also ensures the safety of the consumers of the products due to nearly all the microbes being killed, so the drinker can't get sick because of it.

Although health and food is a huge benefit to the evolution and introduction of modern chemistry, It also has has a distinct impact on the development of technology in the field of LCD's, due to the introduction of the actual liquid crystal used in LCD screens in the form of 5CB. 5CB is the shorter name for 4-Cyano-4'-pentylbiphenyl, which was synthesized in 1972, and had the chemical formula of C1 8H 19 N. This substance is a liquid crystal, which means it has qualities of both conventional liquids and conventional solids, however, they also have qualities such as birefringence which is when a substance has a different refractive index based on the polarisation of light. LCD screens works by having a huge white light at the back of it, and there being multiple screens in front of it. These include 2 layers of glass, 2 polarising filters and an 5CB panel. When the light goes through the 2 polarised filters and the 5CB does not have a current running through it, the light does not show, however, an electronic switch allows for the 5CB to rotate the polarised light, which turns off the light. This is controlled by the whole screen in order to make pictures, and the text that you see every time you use an LCD object, such as televisions and computers.

While it is quite obvious to understand how chemistry has changed our lives in terms of technology, it also affects us in a very physical sense as well. When it snows too hard, the road can become extremely icy. This means that cars usually slide on the ice. This is due to the increased pressure from the tires increases the melting point, which creates a thin layer of water on top of the ice. This same idea is used when we ice the road in order to melt the ice, however, instead of using pressure to increase the melting point, we instead alter

alter the ice's chemical composition by applying salt, or sodium chloride. This works because when the salt is in the water, it gets dissociated into positive sodium ions and negative chloride ions. These have opposite charges, so they attract each other. Because of this, more energy is needed to break up the ions, so the melting point is higher. This means that when we salt roads, the melting point of the ice rises so the icy roads melt into water.

Certain chemical innovations have been detrimental in the long term, such as the burning of fossil fuels in order to create energy. This involves digging up sources, such as: oil, coal, charcoal and burning them in order to heat water, which turns a generator, inducing electricity. All of the fossil fuels contain carbon, so when these are burnt they produce carbon dioxide as a product. This is released into the atmosphere which contributes to global warming as they more efficiently absorb heat, which can further heat the atmosphere due to more kinetic energy being in it at any point. This creates a cycle of positive reinforcement due to the heating melting the ice, which is white and shiny and therefore reflects a lot of heat, which means more heat is being absorbed into the ground. This was good for the progression of the human race due to it leading us to be able to power bigger machines, so we could build bigger machines like cranes and cars, so we could progress as a species.

Other methods of harnessing energy using safer methods have been developed such as the use of nuclear power in order to make a huge amount of electricity, with negligible environmental impact. Nuclear power is generated in the same fashion as coal burning, in that they heat water and the steam turns the paddle which turns the generator which induces electricity. It differs, however, in the method of heating the water. While coal burning involves reacting the fossil fuels with oxygen and releasing all of the excess gasses, nuclear power uses unstable isotopes that decay into two smaller daughter cells. Through this process, kinetic energy is released and so is a subatomic particle. This particles is released at an extremely high velocity, and when it collides with another unstable isotope it causes this particle to decay. This is a controlled chain reaction, as one reaction only releases the particles to decay one more isotope, so the rate is at a controlled rate that doesn't change. Millions of these reactions releases a large amount of kinetic energy, which can excite particles in the water, heating it up. The nuclear waste is put in storage cells underground, so as they do not corrupt the surroundings.

As you can see, chemistry is the main reason for the progression of humans as a race, both health wise and technology wise. Without the development of chemistry, nearly all of the things that we use every day would not work. Without chemistry or chemicals at all, nothing would exist. For these reasons, not only does chemistry change the world, chemistry dictates the world.

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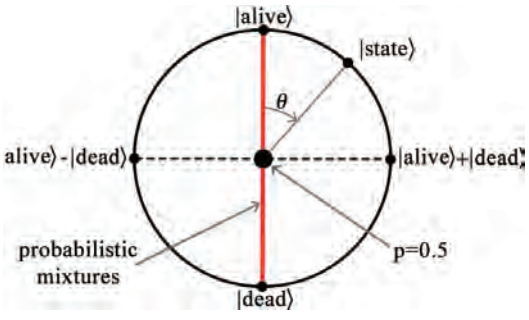
Dead Or Alive?

Dharesha Jhaveri Year 12



You are given three things: a vial of poison that will be released by a radioactive source, a steel box and finally a cat. You place the cat and the vial of poison in the steel box, close the box shut so nobody can see inside. After a while you question whether the cat is alive or dead?

Due to the random decay of the radioactive source, the observer can no longer affirmatively declare whether the cat is alive or dead, therefore, at this stage the cat is both alive and dead, all at the same time? Although this description of the experiment was simplified, it still follows the fundamentals of Schrodinger's cat thought experiment. This paradox demonstrates the idea of quantum superpositioning, explicitly the inherent behaviour of subatomic particles being placed in a state of probability until observed.

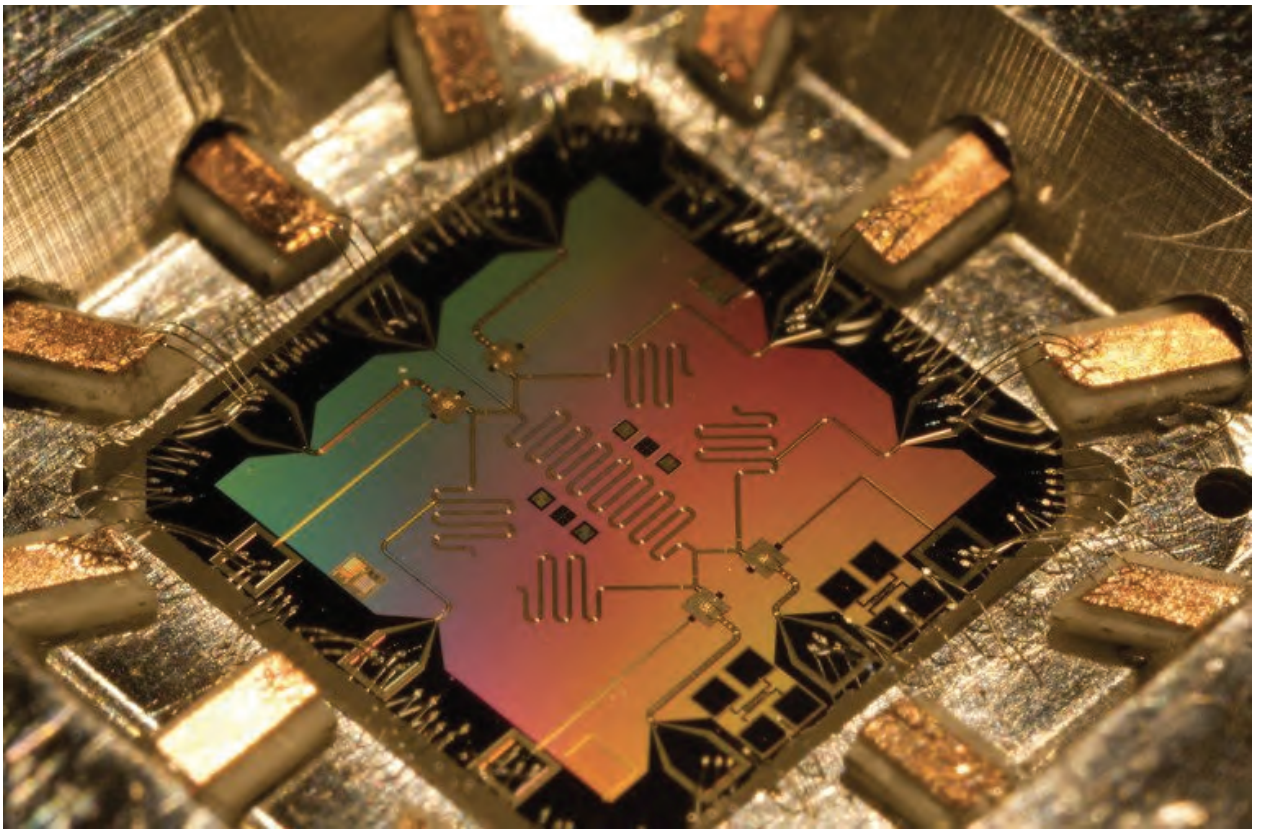
Firstly can cats really be dead and alive at the same time? This is a major misconception of the thought experiment; Schrodinger's experiment is not proclaiming that being alive and dead is physically possible but otherwise is explaining the various probabilities/states the cat can be in - quantum mechanically one would say that the cat is in a superposition of states.

Let's create a function that determines the cat's outcome and let's let have two variables, one being "alive" and the other being "dying". Whilst the radioactive decay releases the poison at a random rate, the cat can be completely unaffected, partially becoming contaminated by the radiation or even entirely contaminated dying. Therefore if we were to translate this into our function is would look something like this:
"Alive" 100% +"Dying"0% = "Alive" 100%
"Alive" 70% +"Dying"30% = "Alive" 70%
"Alive" 0% +"Dying"100% = "Dying" 100%

These are examples of some of various proportions of the variables the cat can take on, yet it's important to mention that there are infinitely many other probability distributions. This is the basis of quantum superpositioning, and this limbo of various states can mathematically be represented through using a wave function. The wave function utilises complex numbers (imaginary numbers) to display all the possibilities.

After questioning whether what state the cats in, you open the lid of the steel box, to find that in this case the cat is dead. The act of opening the box is the observer taking a measurement on the system, for it to reveal the outcome. When a measurement is taken, the wave function is said have collapses, as all but one of the probability collapses down to 0, and that one will be the state in which the system is actually in. In our scenario, where the cat is alive the alive variable will reduce to 0, whilst the dying variable will be 1, bringing us the outcome of dead :"Alive" 0% +"Dying"100% = "Dying" 100%

Although it provides a sufficient analogy, a cat is not a quantum object because an organism cannot simultaneously be alive and dead. However, a system that is known lives in the subatomic world- electrons. Electron state is determined by the vector for electron spin: electrons that spin up are 0 whilst electrons that spin down are 1. The measurement process for this system is when a photon interacts with an electron to disclose the final outcome.



Applications of quantum mechanics/behaviour

Although it is still theoretical, quantum computing opens up doors for fast and efficient data processing and understanding the quantum realm of physics through simulations.

Current computers have three main components: main memory that stores the data, an arithmetic unit that is used for processing data and a control unit which has all the control mechanisms. Inside these control units are computer/circuit chips that constitute of modules, those contain logic gates and finally the logic gates comprise of transistors. Transistors are data processors and behaves similarly to a switch where there are two options either open or block the route for information to come through. Information is made up of bits, these are binary therefore can only take one the value of 1 or 0. To present complex information a combination of bits are employed. Quantum computers use a qubit -a new way of presenting information- which is a combination of quantum and bit.

For a classical 4 bit string of information there are 16 configurations, however through processing, the computer will only present one out these 16 configurations. Whereas for a 4 qubit string of information the computer can take on display all 16 configurations. Evidently this property of quantum computers presents an advantage in storing information and processing information rapidly.

However, this is only true in the theoretical worlds of physics and mathematics, as physical limitations i.e in materials, prevent us from constructing these computers. Even if they were to become reality, the chance of these computers our everyday computers is minimal, as our computers do not require these quantum properties. Moreover, if quantum computers are made they will pose a threat to data security i.e protection of passwords, credit card information, as these computers would be able to decode private credentials in a matter of seconds. Nevertheless the world of quantum computing awaits its introduction on earth.

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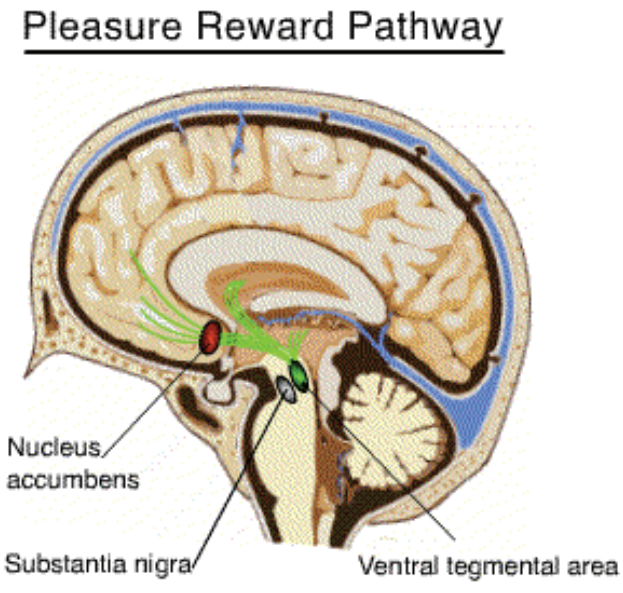
The Science Of Addiction

Millie Cummins Year 12

Addiction: the fact or condition of being addicted to a particular substance, thing, or activity.
To most people, this word conjures up images of drug abuse and alcohol dependence, but addiction is not merely limited to substance abuse, it can also arise in compulsive behaviour towards eating, gambling and sex. The affects of addiction are great, with such habits leading to social isolation, anti-social behaviour and depression, with substance abuse causing further physical damage such as HIV and organ failure. Armed with the knowledge of the great impacts of drugs, it is hard to understand how it is possible for someone to become addicted and reliant on them. To begin to understand addiction, we must examine the motivation addicts have to take drugs, by looking at the reward pathway.

The Reward Pathway



The mesolimbic dopamine system, also known as the reward pathway, is found in the centre of our brains, and drives our feelings of motivation and reward; it encourages us to continue behaviour which we find pleasurable. Its main purpose is to ensure we continue to perform actions which are necessary to our survival, such as eating, drinking and having sex, through positive reinforcement. In order to do this, the pathway transports the neurotransmitter dopamine, after it is made in the ventral tegmental regions of the brain. Unlike dopamine made in the substantia nigra, which is responsible for movement, dopamine made in the ventral tegmental is responsible for causing us to feel motivated and rewarded after performing an action. The mesolimbic dopamine system is connected to the memory centres of our brains, which allows it to transport dopamine to these areas, allowing these centres to focus on particular feelings of pleasure, to ensure the action is repeated.

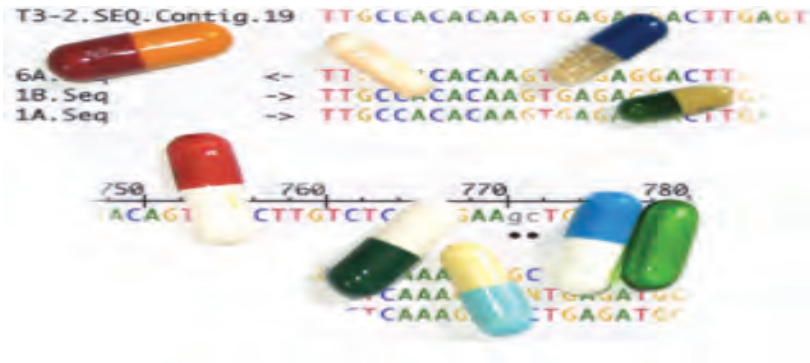
Most drugs provide people with an increased sense of pleasure, a high, by inundating the brain with high levels of dopamine. To counteract the effect of the abnormally high levels of dopamine, the brain responds by lowering the amount of dopamine it produces. This results in the addict experiencing much lower levels of pleasure from things such as food. In certain cases, the addict responds to this by increasing their intake of drugs even more, resulting in a continually worsening reliance on drugs. Over time, drugs take on a similar significance to addicts as food and water - they appear to be necessary to their survival.

The Cause: Nature Vs Nurture

Scientists all over the world engage in the debate of what truly causes addiction, arguing over whether it can be blamed on our genetic makeup, or the environment and experiences we grow up with. Many have settled on the theory that it is a mixture of both, coming from a family with a history of addiction does not mean you are destined to be an addict, or vice versa. However, it is widely recognised that people are more or less susceptible to addiction depending on their biological makeup, with many scientists believing genes are responsible for 40-60% of addiction. To prove this scientists have used mice, as they have a similar reward pathway to humans, to form links between the genes in our bodies and addictive drugs. For example, the A1 allele of the dopamine receptor gene DRD2 was found to be prevalent in people addicted to alcohol or cocaine. Similarly, mutated mice with a defective Per2 gene drink three times more alcohol than normal. Many other connections have been discovered between genes and addiction, some of which can be found here. One of the benefits of identifying a gene linked to addiction, is that the gene can become a drug research target, meaning researchers can focus on creating a drug that alters the activity of that specific gene, which in turn will help combat addiction.To support the argument that addiction can also be caused by environmental factors, psychologists have found that social isolation and psychological trauma, especially when experienced at a young age, are precursors of addiction.

Furthermore, exposure to drugs in early teenage years, before the age of fifteen, has been linked to having a higher chance of addiction, as the brain is not yet fully developed, and is more malleable. The prefrontal cortex, the part of the brain responsible for assessing situations and controlling impulses, is not yet fully developed, meaning that many adolescents are more likely to take risks and experiment with drugs.

Ultimately, we will probably never know what causes addiction, as this will vary person to person. However, as scientists and psychologists research further and develop more links between genes and addiction, and life experience and addiction, we will be able to better understand the pathway to addiction, and hopefully put in place more effective measures to prevent addiction.



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